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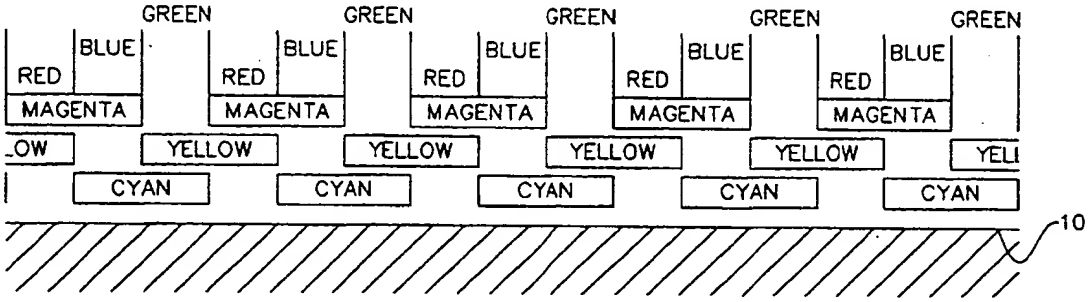

(57) Abstract

The disclosure is directed to providing a color filter for a display comprising discrete elements, such as a liquid crystal display (LCD) using superimposed paired dots of subtractive colors resulting in additive color dots. Black bands can be provided around the resulting additive color dots by superimposing rings or bands of all of the subtractive colors about each dot. Various techniques can be used to obtain the color filter which requires only three layers versus four layers for prior art filters, one for each of three additive colors and a black layer.

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COLOR FILTER DISPLAY

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to a method for constructing a filter for a color display, and more particularly, to a color liquid crystal display (LCD), utilizing subtractive dyes overlaid in pairs to provide additive colors, and the product thereof.

Description of the Prior Art

At present, for LCD applications, color is created by utilizing dyes deposited on a layer of polymer, typically a polyimide material. This material is then colored with additive dyes, red, green and blue. Alternatively, the colors of red, green and blue can be incorporated into a polymer prior to its deposition on an LCD. The first of these methods is called a postprocess, and the second is called a predyed process or pigmented process. The dyes utilized in these prior art processes are obtainable from a number of chemical families, but they must have spectral transmission characteristics which will yield the additive colors red, green and blue. In order to obtain good color purity the concentration and thickness of the dyed layers must be adjusted to optimum values. Due to the nature of the color selection mechanism, peak light transmission drops significantly as color selectivity increases. Therefore, the truer the color, the higher the intensity light source needed. Furthermore, the number of additive color dyes which can be used is relatively limited due to various compatibility requirements, such as that the dye must not be soluble in the liquid crystal material but it must be soluble in the polymer and it must be light fast and not change color when irradiated with white light.

Significantly, utilizing present prior art processes, color filters for LCDs are made through the formation of the three additive color layers and one black filter layer. Thus, the prior art techniques produce four layer filters, comprising red, green, blue and black layers. Prior art processes are inherently disadvantageous, requiring four well-aligned photo process steps. Failure to precisely align all four layers allows bright white light leaks around the pixels or dots.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a method for constructing a filter for a color display, such as an LCD, comprising the steps of depositing a plurality of layers of dots or pixels of selectively overlapping subtractive dyes on a substrate comprising a matrix of pixels or dots to be superimposed with a layer of corresponding discrete elements, such as LCD elements, to provide a full color display. Three layers of subtractive dyes are used and the colors of the dyes preferably comprise magenta, yellow and cyan, the dyes used being inert to the liquid crystal medium. The pairs of subtractive dye dots are superimposed to provide resulting additive colors. Black bands can be provided around the resulting color dots by providing superimposed bands of all the subtractive dyes around each color dot. The invention also comprises a method for constructing a filter for a color display, such as an LCD, comprising the steps of, on a substrate comprising a matrix of dots to be superimposed with a layer of corresponding discrete display elements, such as LCD elements, depositing a layer of magenta dots corresponding to overlapping blue and red dot areas, insolubilizing the magenta layer, depositing a layer of yellow dots over corresponding overlapping red and green dot areas, insolubilizing the yellow layer, depositing a layer of cyan dots over corresponding overlapping blue and green dot areas, and insolubilizing the cyan layer. Black bands can be provided by depositing superimposed bands of each subtractive color around each color dot.

An alternative embodiment comprises a method for constructing a filter for a color liquid crystal display comprising the steps of, on a substrate comprising a matrix of dots to be superimposed with a layer of corresponding discrete display elements, such as LCD elements, depositing a layer each of precursors of three subtractive dyes, photosensitizing each of the layers, exposing the photosensitized layers to a mask having a selected color pattern, and developing the exposed photosensitized layers to provide the filter desired. Black bands can be provided around each color dot by providing the mask with black bands.

The invention also comprises a color LCD comprising a layer of LCD elements, a substrate comprising a matrix of dots superimposed with said LCD elements on said layer, each of said dots comprising a pair of superimposed subtractive dye containing dots to provide an additive color pixel. The subtractive dye layers preferably number

three. The invention can be practiced by disposing overlapping rings of all of the subtractive dyes around each of the dots to provide black bands around the dots.

OBJECTS AND ADVANTAGES OF THE PRESENT INVENTION

One object of the present invention is to reduce the number of dye layers required in a color display, such as an LCD.

Another object of the invention is to reduce the amount of light required to satisfactorily illuminate a color display, such as an LCD.

One advantage of the present invention is that a wider variety of dyes than in prior art processes are available.

Another advantage is that the present invention reduces alignment problems inherent in prior art techniques.

Other objects features and advantages of the invention will become apparent to those skilled in the art from the description of the preferred embodiment, claims and drawings hereof wherein like numerals refer to like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows transmission as a function of wavelength utilizing a typical prior art additive color filter for an LCD;

Fig. 2 illustrates transmission as a function of wavelength for a color filter for an LCD utilizing subtractive colors in accordance with the present invention;

Fig. 3 is a cutaway side view of an LCD color filter utilizing subtractive dyes in accordance with the present invention; and

Fig. 4 shows how all three subtractive dyes can be overlapped to provide a black band around a dot.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

Fig. 1 illustrates typical prior art additive color filter light transmission for an LCD. White light is filtered so that blue, green and red wavelengths pass through discrete pixels or dots superimposed over individual LCD elements. As can be seen, peak transmission occurs only over relatively narrow wavelength bands for each of the blue, green and red color components. Hash marks on the curves for the blue, green and

red denote where light transmission can be selected to preferably occur for each of the additive colors. The purer the colors desired, the closer the hash marks representing light transmission need to be. Therefore, it takes a relatively intense light source to satisfactorily illuminate a high quality color LCD under bright daylight conditions so that a pilot or a person in daylight or in a well-illuminated room can get a clear full color representation on an LCD.

Reference is now made to Fig. 2 which shows transmission of light through a filter utilizing paired overlapping subtractive colors in accordance with the present invention. As seen therein, more of the incident light is actually transmitted through a filter of the invention than through the prior art additive color filter. That greater amounts of light are actually utilized can be evidenced by integrating the areas under the curves and between corresponding hash marks in Fig. 2 and comparing them to integrals of areas of transmission under the curves between hash marks in Fig. 1. Fig. 2 shows the magenta and cyan combine to provide blue; cyan and yellow combine to provide green; and yellow and magenta combine to produce red, all three of the additive colors utilized in a color LCD filter.

Fig. 3 illustrates how, in accordance with the invention, subtractive colors can be layered on a substrate 10 in constructing a color LCD filter. Two processes will be described herein, although those skilled in the art will recognize that other processes can be used to construct a product utilizing subtractive dyes to fabricate a color filter for an LCD in accordance with the invention.

Fig. 4 shows how, in order to provide black bands around resulting additive color dots, bands of all three of the subtractive dyes can be superimposed in any of the embodiments of the invention.

A first embodiment can be practiced by depositing a first layer of magenta over the pixels or dots which are to be utilized for the red and blue components in the display. This is followed by a chemical or thermal treatment to insolubilize the magenta layer. A second layer of yellow is then deposited over the red and green dot areas. The yellow layer is similarly treated to insolubilize it. At this point there are three colors, the yellow where the eventual green dots will go, magenta where the eventual blue dots will go and red dots. A third layer of cyan is then deposited over the blue and green dot areas. This completes the color set of red, green and blue dots. Those skilled in the art

will recognize that the magenta, yellow and cyan layers can be deposited in any order and that the layer order described is for purpose of illustration only.

An alternative embodiment is to deposit three layers of dissolved subtractive dye precursors, one dye precursor per layer. The layers are then photosensitized as in the processing of photographic transparencies, exposed to a mask of dots providing the color pattern desired and developed as in normal color transparency development. In this particular embodiment, all of the layers are present at the same time, which eliminates the possibility that coating non-uniformities will develop as a result of the presence of a previous pattern influencing subsequent layer depositions.

In more detail, a substrate to be used in fabrication of a filtered display is coated sequentially with layers containing the precursor materials for magenta, yellow and cyan dissolved in a suitable binder medium. The color pattern is created by either sequential exposure of the three patterns through appropriate color masks (negatives), or preferably, by a simultaneous exposure to a composite negative pattern. The exposure can be accomplished by either contact or projection methods. Subsequent to the exposure, the substrate is treated with a development process such as is well-known in the color transparency art.

In practicing the invention, those skilled in the art will appreciate that cost savings result because fewer steps are necessary to construct a color filter for an LCD. Also, far more subtractive dyes are available than are additive dyes since the photographic industry has created literally millions of subtractive dyes. This results in an ability to select the color properties much more freely than with present processes.

Those skilled in the art will appreciate that a color filter in accordance with the invention can be used with other displays having color patterns, such as CRTs, electroluminescent (EL) displays, field emission displays, electrochromic displays, and the like.

This invention has been described herein in considerable detail in order to comply with the Patent Statutes and to provide those skilled in the art with the information needed to apply the novel principles and to construct and use such specialized components as are required. However, it is to be understood that the invention can be carried out by specifically different equipment and devices, and that

various modifications, both as to the equipment details and operating procedures, can be accomplished without departing from the scope of the invention itself.

CLAIMS

The embodiments of the invention in which an exclusive property or right is claimed are defined as follows:

1. A method for constructing a color filter to be used in a color display comprising the steps of:

on a substrate comprising a matrix of dots to be superimposed with discrete display elements, depositing a plurality of layers of selected superimposed dots of subtractive dyes to provide a full color display.

2. The invention of claim 1 wherein three layers of dots of subtractive dyes are used and paired layers of superimposed dots of subtractive dye provide dots of three additive colors.

3. The invention of claim 2 wherein the subtractive dye colors comprise magenta, yellow and cyan.

4. The invention of claim 1 wherein selected pairs of dots of subtractive dyes are superimposed to provide a matrix of additive color dots.

5. The invention of claim 4 wherein the selected pairs of dots of subtractive dyes are superimposed to form additive color dots and all of the subtractive dyes are overlapped in bands about the selected pairs of subtractive dye dots to provide black bands around the resulting additive color dots.

6. The invention of claim 1 wherein the color filter is for use with a liquid color display, the step of preselecting the dyes to be inert to the liquid crystal medium.

7. A method for constructing a filter for a color display comprising the steps of:

on a substrate comprising a matrix of dots to be superimposed with a layer of corresponding discrete display elements;

depositing a layer of magenta dots corresponding to overlapping blue and red dot areas, insolubilizing the magenta layer, depositing a layer of yellow dots over corresponding overlapping red and green dot areas, insolubilizing the yellow layer, depositing a layer of cyan dots over corresponding overlapping blue and green dot areas; and

insolubilizing the cyan layer.

8. The invention of claim 7 further comprising superimposing bands of magenta, yellow and cyan around each resulting additive color dot of red, blue and green, to provide black bands around each additive color dot.

9. The invention of claim 7 further comprising the step of preselecting the subtractive color dyes to be inert to a liquid crystal display medium.

10. A method for constructing a filter for a color display comprising the steps of:

on a substrate comprising a matrix of dots to be superimposed with a layer of corresponding discrete display elements, depositing a layer each of precursors of three subtractive dyes, photosensitizing each of the layers, exposing the photosensitized layers to a mask having a selected pattern of color dots, and developing the exposed photosensitized layers to provide the filter desired.

11. The invention of claim 10 further comprising the step of preselecting the subtractive color dyes to be inert to a liquid crystal medium.

12. A color display comprising:

a layer of discrete display elements; and

a substrate comprising a matrix of additive color dots superimposed with said discrete display elements on said layer, each of said additive color dots comprising a selected pair of superimposed dots of subtractive dye to provide an additive color dot.

13. The invention of claim 12 wherein subtractive dyes are disposed in superimposed ring areas around each of said resulting additive color dots to provide black bands around said additive color dots.

14. The invention of claim 12 wherein said display is a liquid crystal display and said substrate is inert to any material within the liquid crystal medium.

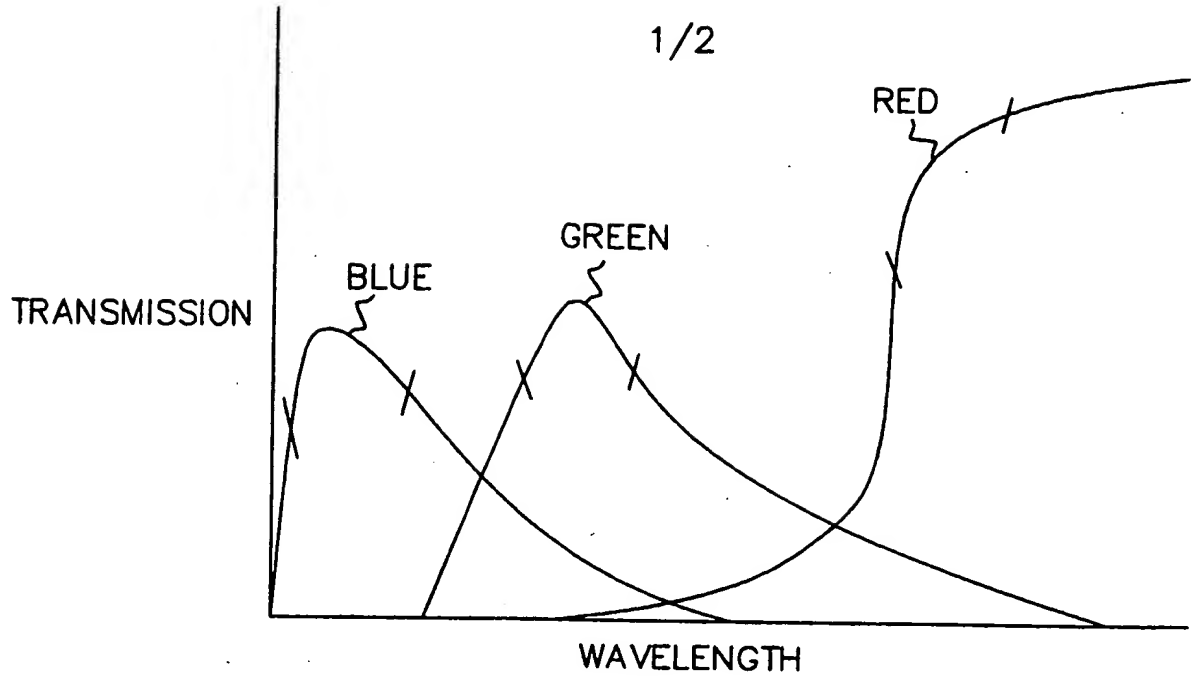

Fig. 1 PRIOR ART

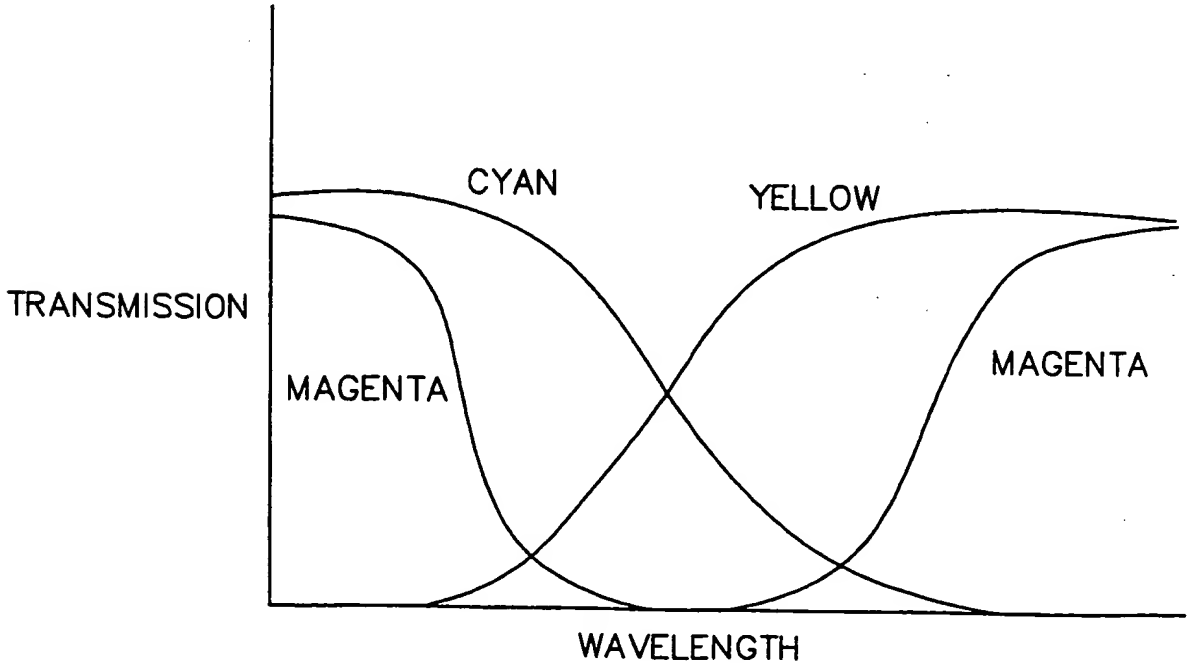

Fig. 2

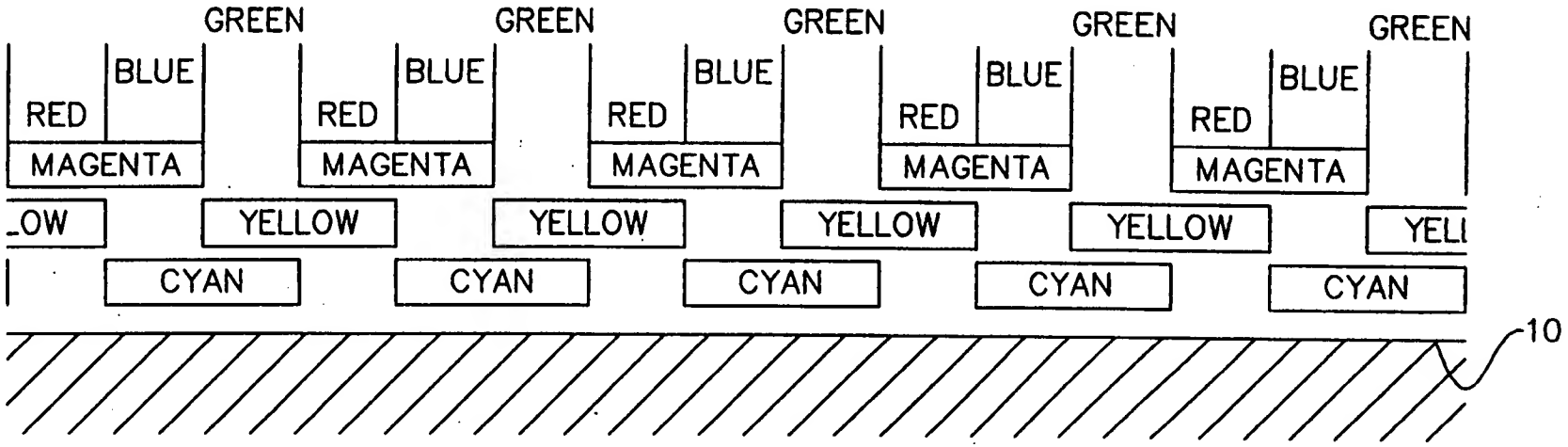

Fig. 3

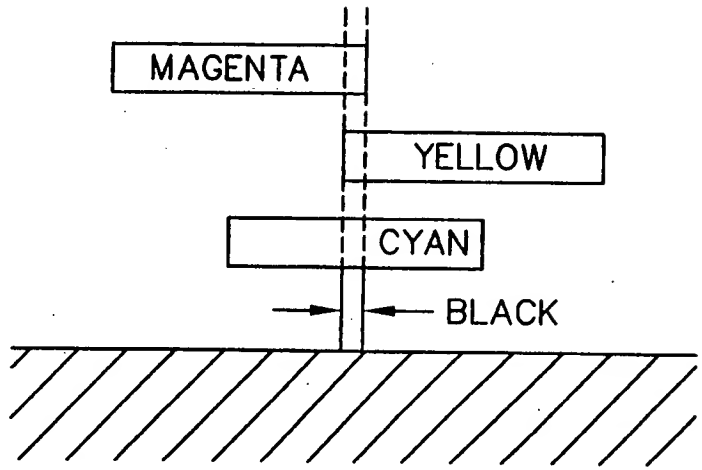

Fig. 4

PCT/US94/06719

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/US 94/06719

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 G02F1/1335

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 9, no. 296 (P-407) (2019) 22 November 1985 & JP,A,60 133 427 (SHARP K.K.) 16 July 1985	1-6,12, 13
A	see abstract	7,8

X	EP,A,0 249 991 (EASTMAN KODAK COMPANY) 23 December 1987	1,4,7,8, 12
A	see page 3, line 9 - page 5, line 7 see page 6, line 6 - page 7, line 15 see figures 1-4,6	2,3,6

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[X] Further documents are listed in the continuation of box C.

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Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PROCEEDINGS OF THE SID, vol.29, no.1, 1988, NEW YORK, USA pages 105 - 107 T. UENO ET AL.: 'High-Quality Organic-Pigment Color Filter for Color LCD' see the whole article	1,4-6,12
A	---	7
A	OPTICAL ENGINEERING, vol.23, no.3, May 1984, BELLINGHAM, USA pages 247 - 252 T. UCHIDA: 'Multicolored liquid crystal displays' see the whole article	1-5,7,8, 10,12

INTER. .TIONAL SEARCH REPORT

Information on patent family members

Inter. nal Application No
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0249991	23-12-87	CA-A-	1293879	07-01-92
		DE-A-	3772461	02-10-91
		JP-A-	63066505	25-03-88
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